*भारतीय मानक*
*Indian Standard*

**IS 17022 : 2018**
**(Reaffirmed 2022)**

# ग्रीन विनिर्माण प्रथाओं के लिए दिशानिर्देश

# Guidelines for Green Manufacturing Practices

ICS 13.020.10

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**September 2018** **Price Group 6**

Environmental Management Sectional Committee, CHD 34

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Environmental Management Sectional Committee had been approved by the Chemical Division Council.

The existence of mankind solely depends upon natural resources, the availability of which is finite and limited. Therefore, for the sustainability of present and future generations, judicious utilization of resources is of paramount importance. However, variations in the supply and demand curve coupled with the associated environmental burdens due to increasing population and user preferences take precedence over the requisite focus needed to be laid on conservation of environment. Further, the need for growth and development of a country makes it imperative to utilize the resources judiciously to ensure competitiveness and the quality of environment. "Green Manufacturing Practices" are a step towards it.

The concept of 'green' is a philosophy in the approach at each and every stage of business, strategic planning, purchasing, designing, commissioning and operation including decommissioning. To actualize the philosophy of green manufacturing in an organization, the awareness of the purpose and intent of the embedded environmental concepts and principles within the operations, as well as the roles and responsibilities of the people and that of the organization is of great significance. This helps in building the environmental culture and practices within the organization.

Environmental burdens associated with the activities of an organization which causes impacts on environment are global as well as local in nature. Such impacts may result in:

a) Climate Change,

b) Ground water depletion,

c) Soil erosion,

d) Water quality degradation, and

e) Deforestation etc.

However, their significance varies with time and space. Sometimes, market relevance also predominates and decides their significance such as greenhouse gas emissions.

A mechanism to address an environmental issue to a particular geography may not fit elsewhere. Therefore, a solution to a process should always be tailored in line with all the relevant and significant environmental impacts associated to the product or activity in consideration.

Though there is no clear definition for 'Green Manufacturing', one would understand with the available information that, it deals with the manufacturing processes involving technologies which impose less burden on environment. Therefore, requirements for 'Green Manufacturing' invariably are in terms of process and product requirements specific to the environmental aspects associated with them.

To decide the relevance and significance of numerous environmental aspects associated with either process or a product, tools such as 'Life Cycle Assessment', 'Environmental Impact Assessment', 'Material flow cost accounting', 'Carbon Footprint' and 'Water Footprint' etc. may be applied to identify them throughout the life cycle of the product. Based on the results of such assessment methods, one could identify the environmental impacts that should be addressed by the technology.

This Guideline Standard attempts to provide doable action by the new industry (projects) as also by the existing industry pursuing the concepts of Green Manufacturing. The aim of this Indian Standard 'Guidelines on green manufacturing practices' is to offer a general framework for efficient manufacturing management for the purpose of understanding the potential resource and environmental consequences of infrastructure or manufacturing activities including materials and energy use practices. Objectives of such exercise could be many for such purposes, out of which the important ones for example are:

a) To design and establish the new projects with all measures which in turn results in resources and energy conservation.

b) To choose better technologies in place of existing technologies in the context of optimum utilization of resources and energy conservation.

(*Continued on third cover*)

*Indian Standard*

# GUIDELINES FOR GREEN MANUFACTURING PRACTICES

## 1 SCOPE

This Indian Standard provides guidelines and framework on “Green Manufacturing Practices” for all types of industries and organizations including service sector.

## 2 REFERENCES

The Standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

| *IS No.* | *Title* |
|---|---|
| IS/ISO 14040 : 2006 | Environmental management — Life cycle assessment — Principles and framework |
| IS/ISO 14044 : 2006[1] | Environmental management — Life cycle assessment — Requirements and guidelines |
| IS/ISO 14051 : 2011 | Environmental management — Material flow cost accounting — General framework |
| IS/ISO Guide 64 : 2008 | Guide for addressing environmental issues in product standards |

NOTE — For reference to other publications, please *see* Bibliography (Page 12).

## 3 TERMS AND DEFINITIONS

### 3.1 Design

A creative activity that is based on expressed or implied needs, existing means and technological possibilities, results in the definition of technical solutions for a product or process that can be commercially manufactured or fabricated into prototypes.

### 3.2 Energy

Power derived from the utilization of physical or chemical resources, especially to provide light, heat and/or to work machines.

### 3.3 Energy Flow

Input to or output from a unit process or product system, quantified in energy units.

### 3.4 Environment

Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation.

### 3.5 Environmental Aspect

Element of an organization’s activities, products or services that can interact with the environment.

### 3.6 Environmental Impact

Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization’s activities, products or services.

### 3.7 Environmental Outputs

Toxic chemical releases, toxicity-weighted chemical emissions, ozone depletion potential, conventional air pollutant emissions, global warming potential, hazardous waste generation. Where possible, the social costs of these outputs are also quantified.

### 3.8 Evaluation

Element within the life cycle interpretation phase intended to establish confidence in the results of the life cycle assessment.

### 3.9 Full Cost Accounting

Assigns the costs of materials, energy, labor, waste disposal, and other costs to specific products or processes instead of lumping them in an overhead account, to recognize the true burden of their environmental impacts.

### 3.10 Green Auditing/Accounting

Identifying and measuring the costs of environmental materials and activities so as to use this information for management of environmental impacts.

### 3.11 Green Manufacturing

The use of manufacturing technologies that minimize environmental impacts such as emission of greenhouse gases, use of non-renewable or toxic materials, and waste generation etc.

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[1] Superseding IS/ISO 14041 : 1998, IS/ISO 14042 : 2000 and IS/ISO 14043 : 2000.

**3.12 Input**

Product, material or energy flow that enters a unit process.

**3.13 Interested Party**

Individual or group concerned with or affected by the environmental performance of a product system, or by the results of the life cycle assessment.

**3.14 Life Cycle**

Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.

**3.15 Life Cycle Assessment**

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

**3.16 Life Cycle Inventory Analysis**

Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

**3.17 Mass Balance**

Exercises consider inputs and outputs of a process and determine effectiveness of utilization and wastages in time and money.

**3.18 Output**

Product, material or energy flow that leaves a unit process.

**3.19 Process**

Set of interrelated or interacting activities that transforms inputs into outputs.

**3.20 Process Energy**

Energy input required for operating the process or equipment within a unit process, excluding energy inputs for production and delivery of the energy itself.

**3.21 Product**

Any goods or service.

**3.22 RawMaterial**

Primary or secondary material that is used to produce a product.

**3.23 Recyclable Material**

Material for which an economically and technically feasible recycling method exists.

**3.24 Recycled Materials**

Materials that have been recovered, or otherwise diverted, from the waste stream, either from the manufacturing process [that is, post-industrial recycled materials, but not in-house scrap or after consumer use (that is, post-consumer recycled materials), and are reused in the manufacture of new products.

**3.25 Renewable Materials**

Materials that have been produced from a source, usually plant or animal biomass, that can be renewed by short- to medium-term regeneration.

**3.26 Resource Inputs**

Raw materials, water, electricity, fuels, ores etc.

**3.27 Sensitivity Analysis**

Systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study.

**3.28 Variable Frequency Drive**

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.

## 4 PRINCIPLES AND CONCEPTS OF GREEN MANUFACTURING

The aim of green manufacturing is to reduce adverse impacts of a process or product on human health and to virtually eliminate environmental impacts. Green manufacturing provide framework for alternative, environmentally friendly processes and practices to balance increase of process efficiency and lowering of environmental burdens simultaneously.

### 4.1 Design

**4.1.1** *Design Less Polluting Manufacturing Processes*

Where feasible, make use of equipment, processes that pose least or no threats to human health and the environment.

**4.1.2** *Taking Advantage of Products Designed for least Degradation*

Reduce the effect on the environment by developing products that are designed with least burden on the environment for example, biodegradable.

### 4.2 Process

**4.2.1** *Process Efficiency*

An efficient process ensures that the maximum amount of input materials is converted to the final product so as to minimize waste as residues. Process conversion should be the maximum or emphasis to be given to economy and selection of various requisite materials. Conversion could also depend on the catalyst that is used. Thus, eco-catalyst should be used even if they are costlier.

**4.2.2** *Waste Minimization and Prevention*

Development of manufacturing techniques, which reduce or prevent waste. It is better to prevent waste than to clean it up after its creation.

**4.2.3** *Establishment of in-process Controls for Pollution Prevention*

To avoid formation of hazardous by-products/residues, adopting real-time analysis and in process monitoring during manufacturing.

## 4.3 Resources

**4.3.1** *Materials*

**4.3.1.1** *Use safer material*s

Use material/chemicals that have the lowest levels of environmental load and toxicity.

**4.3.1.2** *Accident prevention*

Selection of materials/substances that minimize the potential for explosions, fires and releases into the environment.

**4.3.1.3** *Use of alternative and renewable feedstock*

Use of alternative materials or renewable or recycled materials (waste from other processes or products derived from agricultural streams etc.) whenever technically or economically feasible.

**4.3.2** *Energy*

**4.3.2.1** *Enhanced energy efficiency*

The realization of the economical and environmental impact of energy use in a chemical process and the development of alternative means to reduce the impact.

**4.3.2.2** *Enhanced water efficiency*

Selection of water efficient equipment, processes and following practices including reuse, recycle, use of rainwater etc.

**4.3.3** *Safety and Health*

**4.3.3.1** *Usesafer reaction conditions*

Search for the most up-to-date information on green inputs that will optimize the process and provide a safer working environment.

# 5 GREEN MANUFACTURING FRAMEWORK

## 5.1 General

Sustainable manufacturing or green manufacturing involves processes that are:

a) Non-polluting,
b) Conserve energy and natural resources,
c) Economically viable, and
d) Safe for workforce, communities and consumers.

## 5.2 Green Factory

The manufacturing facility/factory shall be designed and constructed in way to enhance higher efficiency and optimal utilization of resources to produce eco-friendly/green products. This requires close cooperation of the design team, the architects, the engineers, and the client at all project stages. The primary objective of green factory shall be able to reduce the overall environmental impact of the product/process on human health and the natural environment by:

a) Efficiently using energy, water, and other resources;
b) Protecting occupant health and improving employee productivity; and
c) Reducing waste, pollution and environmental degradation.

**5.2.1** *Location*

In case of new project, more preference shall be given to the site/location which:

a) Is closer to the primary source of raw material to reduce emissions, leakages during transport;
b) Better connected via rail/road/sea or all the three modes to utilize the environmental friendly transport;
c) Proximity to the primary/potential market to keep the supply chain/value chain within the project boundary if possible;
d) Availability of sufficient and reliable energy from national grids/bulk supplies;
e) Easy availability of water, work force and raw material, excess of which could be recycled;
f) Renovate and reuse existing buildings and associated infrastructure instead of building the same anew;
g) The location should also consider the possibility of use of the by-products in industries in the same vicinity;
h) Location preference should include places where the hazardous waste/solid waste can be used for co-processing in nearby industries; and
j) Simultaneously, availability of co-processable hazardous waste/solid waste should be considered.

**5.2.2** *Design, Architecture and Planning*

a) The factory design, architecture and layout shall be able to utilize natural resources like sunlight, water or wind optimally;
b) Implementation of green building concept in offices, stores and warehouses, sub stations, that is use of non-toxic, zero VOC paints, high efficiency windows, insulation in walls, ceilings, floors etc.;

c) Installation and fitting of devices/equipment, which consume lesser energy and resources such as power, water, fuel etc.;
d) Innovation, automation and more application of sensor controlled devises/equipment to conserve electrical energy and other resources;
e) Provision for flexibility in use, function and change in factory layout;
f) Efficient usage of landscape, infrastructure and architecture. For example, smaller and integrated buildings with efficient use of space; and
g) Hire a design team which has green design experience with respect to building and structures.

**5.2.3** *Construction*

Sustainable construction, execution and establishment methodology to be adopted by considering aspects such as:

a) Materials — Selection and use of more sustainable/eco-friendly (namely, renewable, recycled, non-toxic etc.) materials or alternatives with similar/better performance. For example, use of eco labeled products;
b) Selection and adoption of efficient/latest construction technology and processes to help resource conservation;
c) Operation and maintenance — Make provisions for easy operation and (minimal) maintenance with easily available eco-friendly materials/methods in long run; and
d) Ensure occupational health and safety and working conditions.

### 5.3 Green Products

A green product must have lesser impact on environment and shall be lesser detrimental to human health than the traditional product equivalent. Green product shall be manufactured in a green manufacturing facility and should be:

a) Energy efficient, durable and often have low maintenance requirements.
b) Lesser/Free of Ozone depleting chemicals, toxic compounds and do not produce toxic by-products.
c) Often/can be made of recycled materials or content or from renewable and sustainable sources.
d) Obtained from local manufacturers or resources.
e) Biodegradable/recyclable/repairable or easily reused either in part or as a whole.
f) Safe for human and environment.
g) Use of safe/eco-friendly/biodegradable packaging materials.
h) Packaging Materials — Disposable and Environment-friendly.
j) Can have improved shelf life and can be stored safely.
k) Green/Eco-product development through the market research and analysis.

### 5.4 Green Processes

Green process refers to measures to eliminate the environmental burden in such areas as resources input, chemical substances use and energy consumption to the greatest extent possible from all the processes involved in manufacturing the products.

It is the design, commercialization, and use of processes and products, which are feasible and economical while minimizing:

a) Generation of pollution at the source, and
b) Risk to human health and the environment.

It embraces the concept that decides to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of a process or product.

**5.4.1** *Principles of Green Engineering/Process*

a) Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.
b) Conserve and improve natural ecosystems while protecting human health and well-being.
c) Use life-cycle thinking in all engineering activities.
d) Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.
e) Minimize depletion of natural resources.
f) Strive to prevent waste.
g) Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.
h) Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.
j) Actively engage communities and stakeholders in development of engineering solutions.

*Examples:*

1) Using electronic media and technology to reduce paper and fuel;
2) Lead-free soldering for electronics;
3) Use of environment-friendly chemicals; and
4) End of life treatment — Recycling of components, collection of equipment

### 5.5 Green Operation, Supply Chain and Logistics

Supply chains are critical links that connect an organization's inputs to its outputs. Traditional challenges have included lowering costs, ensuring just-in-time delivery, and shrinking transportation times to allow better reaction to business challenges. However, the increasing environmental costs of these networks and growing consumer pressure for Eco-friendly products has led many organizations to look at supply chain sustainability.

Green logistics attempts to measure and minimize the ecological impact of logistics activities. This includes all activities inward and out ward flows of materials/ products between the point of origin and the point of consumption.

**5.5.1** *Materials*

Material selection and usage can lead to reduction in environment burden (*see* Fig. 1):

a) Institutionalize environmental considerations in all procurement decisions ;
b) Materials control-utilize reusable and recyclable materials wherever possible;
c) Promote environment awareness among suppliers/ contractors;
d) Vendor commitment and monitoring;
e) Prefer supplier with better track records on environment, health and safety;
f) Proper Storage management to minimize waste and support production; and
g) Selection of recycled/biodegradable/renewable materials as much as possible.

**5.5.2** *Responsible Sourcing*

Input should not result into any type of pollution, toxic/ hazard in the finished goods/product (*see* Fig. 2):

a) Consider whether a product is needed before purchasing it;
b) Purchase a product considering the various environmental impacts over its life cycle — from extraction of raw materials to disposal;
c) Select suppliers who make conscious efforts to care for the environment; and
d) Collect environmental information on products and suppliers green purchasing to encourage environmentally conscious management and eco-product development through the market.

**5.5.3** *Energy*

a) Use of energy efficient equipment and process;
b) Measurement of consumption;
c) Studying new ways to use technology to minimize energy consumption;
d) Energy savings should be incorporated in a manner that waste energy from a process step is recovered for re-use in another process step;
e) Variable frequencydrives should be considered for all energy intensive rotating equipment with varying loads;
f) Periodic energy audit/electrical system audit may be taken up voluntarily or may be made mandatory;

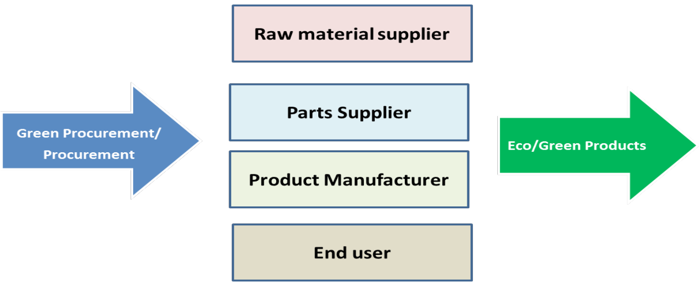

FIG. 1 MATERIAL SELECTION AND USAGE

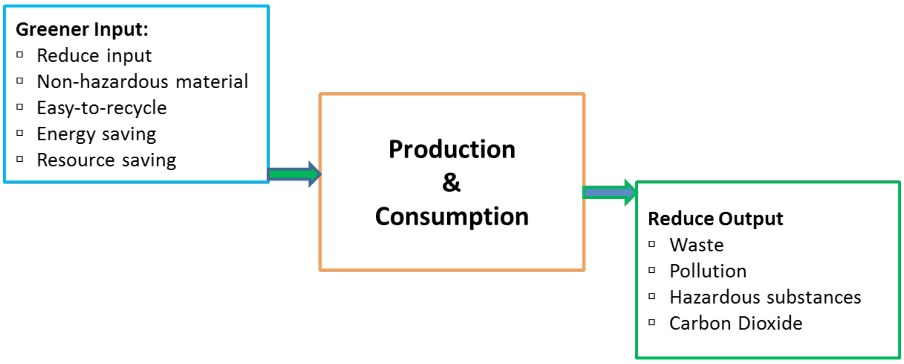

FIG. 2 RESPONSIBLE SOURCING

g) Work environment should be such that it is comfortable for the production workers which in turn would provide higher efficient man power leading to more production per unit of manpower; and

h) Encourage use of bi-cycles within the plant premises in a manner that a bicycle can be picked-up from one location, driven to another location and dropped there. This would ensure saving on fuel used by vehicles within the plant premises.

**5.5.4** *Water*

a) Use of water efficient equipment and process;

b) Measurement of consumption and discharge;

c) Check leakages and waste in the process;

d) Cleaning and reusing water used for manufacturing;

e) Studying new ways to use technology to minimize water usage in life cycle;

f) Metering at each water use point should be a practice so as to reduce water;

g) Use at each point per unit of production;

h) In case of green belts/aesthetic gardening; a practice of growing low water consuming trees/shrubs/lawns should be a practice;

j) Collection of storm water in a collection tank before allowing it to go for sub-soil rain water harvesting would enable use of the collected storm water in the manufacturing process (wherever possible) and thus reduce withdrawal of fresh water for the same;

k) Paving of the land to the maximum possible extent would ensure higher collection of the rain water in the storm water collection tank; and

m) Periodic water foot print assessment may be taken up voluntarily or made mandatory.

**5.5.5** *Logistics and Supply Chain*

A supply chain is the portion of the value chain that focuses primarily on the physical movement of goods and materials, that is, purchasing raw materials and distribution of finished goods to retail outlets:

a) Using transportation modes that minimize costs and carbon output; and

b) Studying new ways to use technology.

**5.5.6** *Packaging*

a) Packaging materials selection — Prefer disposable and environment-friendly.

b) End of life treatment — Recycling of components.

c) Use of biodegradable materials.

**5.5.7** *End of Life Treatment*

“End-of-life” (EOL) is a term used with respect to a product supplied to customers, indicating that the product is in the end of its useful life and a vendor intends to stop marketing, selling, or sustaining it. A green product shall:

a) Aware/guide consumer/customer about the proper handling and disposal method;

b) Responsible manufacture may extend support to customers for proper collection and disposal of product after EOL;

c) Lucrative buy back schemes; and

d) Encourage/train and authorize parties for proper recycling of components and collection of equipment.

## 6 ECONOMIC ASPECTS OF GREEN MANUFACTURING

**6.1** Environmental impact and efficient manufacturing are important to investors who have the access and the control to discuss business practices with management. Consequently, they have the ability to persuade businesses to adopt green practices. The prospect of adoption of these practices is tremendous given the fact that the industry is still developing and large majority of it is classified as a small or medium scale enterprise. Hence the applicability and the economic gains to be derived from these guidelines are very substantial.

**6.2** The average investor and consumer are not likely to knowingly, or actively, invest in a company that blatantly violates environmental standards or human rights. Environmental responsibility, which includes adopting green manufacturing practices, can raise long-run profits, especially if it creates extra benefits such as a better business environment that penetrates all levels of the operation. Consumers and investors have much more access to this information now than they did in the past. This knowledge and increased competition forces companies to be more responsible for their practices. Many firms must choose to be proactive and adopt green strategies or be reactive and change once they are prodded by consumers and investors.

**6.3** As an organization adopting green manufacturing practices, it should also specifically mention its activities in respect to the same in their annual report as an effective means to communicate with the various stakeholders on their initiative to become more sustainable.

## 7 BIODIVERSITY AND CLIMATE CHANGE

**7.1** Conventional risk management often fails to address one of the most significant issues facing many companies today, that is, the environmental and social risks within global supply chains. Unsustainable sourcing can destroy biodiversity and affect communities, threatening future supply and brand reputation and potentially leading to expensive legal disputes.

**7.2** A risk analysis methodology must be followed while assessing the impact on biodiversity and climate change. The methodology adopted by organizations should enable the understanding of risks to biodiversity associated with commodity production and procurement, as well as developing action plans to reduce those negative impacts. It should also facilitate the understanding of relative risk and opportunity within a supply chain to develop an action plan to reduce the footprint of a commodity's production on a global scale. Key vulnerabilities of an organization with respect to climate change could be identified using the criteria listed in Annex A.

## 8 IMPLEMENTATION OF GREEN MANUFACTURING PRACTICES

A well-managed supply chain can create more value for the manufacturing industry in the form of quality products or processes, innovative new goods and services and increasing as well as protecting the brand reputation and enhancing customer loyalty:

a) Company policies should include the green manufacturing prospect and ensure that the green manufacturing practices are reported in annual report. This would ensure that the various stakeholders also know, appreciate and support the stated practices.

b) Companies should adopt green supply chain standards and implement them through inspection and compliance regimes, such as requiring their suppliers to use a certified Environmental Management System (*see* IS/ISO 14001 : 2015)

c) Industry-based green standards can play a crucial role in the design, manufacturing, packaging and end-of-life stages of a product. Industry management standards are often integrated into voluntary environmental management systems, especially those that can be certified by various certifying bodies against International/National Standards.

d) Implementation of green management systems, certified by independent parties, would help developing country manufacturers comply with requisite standards and to verify their performance against those standards. This is especially relevant in instances where enterprises are meeting process-related standards. In addition, management systems can be useful for complying with specific product-related standards, such as Quality Management Standards, Energy Management System Standards for example, IS/ISO 9000, IS/ISO 50001.

e) Energy efficiency can be enhanced by updating electricity infrastructure with smart energy grids. Improved energy efficiency is one of the most cost-effective ways to reduce global GHG emissions, enhance energy security and reduce the amount of money spent on energy. For most industries, increasing energy efficiency in production, therefore, is not just a response to environmental concerns or objectives; it has become a core determinant of economic competitiveness and sustainable growth. Most energy efficiency gains in industry are achieved through changes in how energy is managed in an industrial facility, rather than through the installation of new technologies. Energy management systems, like the IS/ISO 50001 Standard, provide a framework for understanding significant energy use and offer applicable best practices.

## 9 GREENING OPPORTUNITIES ALONG THE MANUFACTURING SUPPLY CHAIN FOR EXISTING ENTERPRISES

**9.1** The manufacturing sector can, regardless of size or location of facilities, continuously reduce the environmental impacts of manufacturing processes and products through:

a) Taking increased extended producer responsibility;
b) Compliance to all environmental standards set by the government;
c) Performing a material, energy and water audit;
d) Using energy and other resources (more) efficiently;
e) Substituting fossil fuels with renewable energy sources;
f) Phasing out toxic substances including but not limited to heavy metals, obsolete pesticides and insecticides, and asbestos;
g) Promoting the sound management of chemicals;
h) Improving occupational health and safety;
j) Looking for superior solutions to waste minimization;
k) Establishing environmental management systems;
m) Upgrading and green retrofitting;
n) Implementation of Management Systems such as IS/ISO 9001, IS/ISO 14001 and IS/ISO 50001, IS/ISO 18001; and
p) Using Life Cycle Analysis tools (IS/ISO 14040, IS/ISO 14044).

**9.2** Enterprises can incorporate the following initiatives to increase awareness and directing a behavioral change within its supply chain:

a) Encourage service providers to disclose their environmental footprint: Service providers can be encouraged to provide verifiable and easily available, comparable and understandable information on the environment footprint of their products and/or services and to support the public dissemination of this information.

b) Identify opportunities to collaborate on the use of sustainable transportation processes and technologies: Collaboration with actors in other parts of the value chain, including both suppliers upstream and customers downstream, can help to develop and scale up the use of sustainable transportation processes and technologies.

c) Create new green industries: Stimulating the development and creation of manufacturing industries that deliver green products can help build up new capabilities in green sectors. This includes companies that manufacture and install renewable energy equipment and companies that develop and produce clean technologies.

d) Advocate and ensure 'supplier's' adherence to green codes of conduct: In response to growing consumer demand for sustainable business practice, organizations shall develop and implement codes of conduct. Also it shall encourage suppliers to ethical environmental practices. By demonstrating adherence to such codes of conduct, businesses in developing economies can significantly improve their export opportunities.

e) Remanufacturing is the process of bringing used products and individual product components to a 'like new' functional state. It recovers a substantial proportion of the resources incorporated into a used product in its first manufactured state, at low additional costs, thus reducing the price of the resulting new product. Remanufacturing is often considered an environmentally preferable end-of-life option in comparison with material recycling or manufacturing new products. This is because, remanufacturing alleviates the depletion of natural resources, helps reduce excess production and also enhances chances to close the loop for recycling of resources including safer handling of toxic materials. (*see* Fig. 3)

## 10 GREENING OPPORTUNITIES ALONG THE MANUFACTURING SUPPLY CHAIN FOR NEW ENTERPRISES

New enterprises have an advantage of addressing *inter-alia* the green concepts, principles, technologies, good management practices, during its project cycle. The environmental aspects and management issues shall vary during each stage of:

a) Project-planning,
b) Design,
c) Raw Material,
d) Construction,
e) Procurement stage,
f) Construction stage,
g) Commissioning,
h) Operation,
j) Supply-chain operations, and
k) Decommissioning.

For the pre-commissioning stage, includes the health and safety as well as social aspects.

During the project planning it is pertinent to consider Environmental Impact Assessment (EIA) and related notifications and guidelines, as well as the guidelines by World Bank, International Finance Corporation (IFC), Asian Development Bank (ADB), Equator Principles, Global Compact/SA 8000 and/or other lender or regulatory specific requirements. At any stage

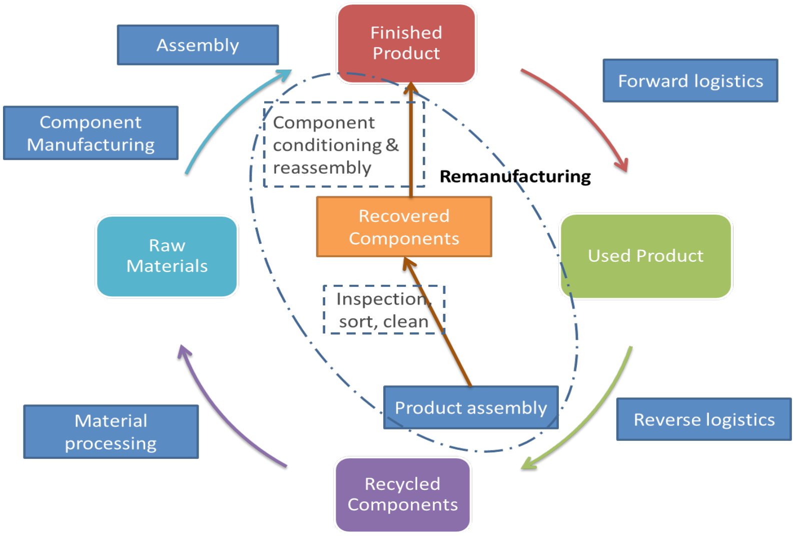

Fig. 3 Schematic Representation of Remanufcturing Process

of the project, for borrowing money or for alliances, adherence to these allows the international acceptability of the company.

New enterprises during its establishment can ensure that sustainability is interspersed within its organizational values by establishing a green supply chain:

a) Setting up green factories — Incorporating building codes, construction materials, natural lighting etc.

b) Extraction of materials (resources) — In this step, resources needed for product manufacturing are collected. Some equipment is used for environmental impact reduction in this stage.

c) Material and component production (materials/parts) — This is a stage where interim products including materials and components are manufactured. Such interim products and their designs are intended for environmental impact reduction.

d) Design and material selection (design) — In this step, designs and materials are carefully selected for product manufacturing, including environmentally compatible designs.

e) Product manufacturing (production) — Products are manufactured in this step using materials and components. This step includes products that help reduce environmental impact during the manufacturing process.

f) Transportation — In this step, materials, parts, and products are carefully transported to result in a low environmental burden. This step includes products for which modes of transportation have been changed and those with unique packaging.

g) Product use, maintenance, and repair (use/repair) — In this step, products are used by consumers and maintenance and repairs are carried out. This step includes consideration of energy saving and environmental cleanup as well as prolonging product life by repairs and product life improvement.

h) End-of-life — In this step, products are disposed of and recycled. Included in this step are products that contribute to the reduction of final disposal volumes and can be disassembled, are easily reusable, easily recyclable, and compatible with well-established recycling systems.

## 11 MEASUREMENTS AND PERFORMANCE INDICATORS

The concept of ‘what can be measured — can be managed’ to be introduced for all measurable parameters and quantified not only to meet “Requirements of Green Standard” but also to demonstrate achievements with facts and figures in the following areas:

a) Energy efficiency;

b) Water conservation;

c) Renewable energy;

d) Greenhouse gas emission;

e) Waste management;

f) Material conservation, recycling and recyclability;

g) Green supply chain;

h) Product stewardship;

j) Life cycle analysis; and

k) Other areas (ventilation, surroundings, site location and innovation).

The life cycle approach and material flow cost accounting may be used as a push for determining environment performance indicators, including financial as well as to engrain the environmental culture. The boundary of the life cycle approach may be limited to company or extended beyond:

a) Activity based cost apportionment of various resource use and consumptions, for example, energy, water, etc. This would require companies to install energy or water meters at point of use.

b) Indicators of resource consumption or wastage per unit production or the costs involved can be estimated, to further refine areas.

c) Benchmarking to own best performance *vis-à-vis* peer industries.

d) Material balances of resources and costs across the company and at unit level, allows for the green mapping.

## 12 PERSONNEL AND COMPETENCE

### 12.1 Awareness, Training and Skills Development

Environmental culture, attitudes and approach of the company is the key for environmental management. To build a culture around green-thinking, companies need to hold awareness and training programme periodically. The training can be of various types ranging from awareness, functional, job based, skill and development based, in alignment with the business vision, strategies, policies, to achieve business focus of short term and long term.

The environmental awareness programme should focus on the environmental purpose and intent of the designed systems and procedures to achieve the effective implementation and building the culture of green manufacturing. While the top-down approach plans the expanse of the business vision and strategies over different time horizon with environmental considerations, by way of technologies, designing, operations, products and processes as well as services, it paves way for bottom up approach to inbuilt environmental planning and implementation. In other words, ‘taking ownership’ of the own processes/function segments/departments and workings to include the green concepts and principles, aligned to business vision and plans is important.

Frequent awareness programs for ideas and innovations within existing framework of implementation and new tools and techniques, is as important as arranging training and awareness programme on how to achieve them. Such awareness programmes allow the participation of people and taking ownership of existing systems and openness to the newness with green thinking. Often, such programmes will allow companies to identify the champions, who can derive the environmental efforts as campaign within the organization.

This also allows the top management awareness of the new tools and techniques, and their cost-benefits, to in-built them into their business planning and strategies, as 'smart options' of taking leadership in business with sustainability.

### 12.2 Competence

a) Competence criteria for the personnel handling key functions should be defined. The competence criteria should be based on qualification, knowledge, experience and skill required to meet the assigned task.

b) As a good practice, key 'environmental roles and responsibilities' of personnel are part of their job profile, to allow them recognizing its importance and take its ownership as well enable in training need assessment resulting from job performance evaluations. These should not be restricted to Environmental or Safety Manager only but extended across.

c) In addition to key personnel at different job functions and levels, all personnel including workers and contract workers, should be included in the awareness and training programmes.

d) Awareness programme are also held on the new areas of environmental tools, techniques, standards, etc.

e) Training need assessment plan is based on the defined roles and responsibilities of the personnel, as well as different routes of training need identification.

f) Training need identification should be aligned to achieve the company's vision and strategies as well.

g) Awareness and Training plans should be dynamic and relevant to the personnel at the given time.

Organizations to Ensure that Awareness and Training ProgrammeAddress

a) The identified environmental roles and responsibility of the personnel within the department and at company level.

b) How to realize their defined environmental roles and responsibility.

c) Knowledge of the potential benefits and significance of achieving the environmental performance.

d) Knowledge of the potential consequences of the departure from the systems and procedures or instructions.

e) Skill enhancements of key environmental functions and operations.

f) Conditions of environmental regulations, roles, and responsibilities of various functions and personnel.

### 12.3 Indicative List of Areas of Training

a) Adoption and adaptation of new technologies or modifications or renovations.

b) Planning of the calibration of process control parameters that can affect the environmental performance, for example, air emissions.

c) Clear work instructions with close ended statements and performance parameters.

d) Use of pictorial depictions in the work instructions as well as point of functioning.

e) Formation of groups with champions for significant environmental aspects and impacts for identifying areas of improvement.

f) Environmental monitoring techniques and measurements.

g) Environmental regulatory parameters or those covered under the covenants.

h) Emergency preparedness and response work instructions on actions, reporting lines and command and control structure, emergency contacts and help lines within the company, outside and those in the vicinity company facilities.

j) Green supply chain, including vendors or subcontractors who undertake their jobs with consideration of environmental aspects and impacts.

# ANNEX A

( *Clause* 7 )

## CRITERIA FOR IDENTIFICATION OF KEY VULNERABILITIES OF AN ORGANIZATION WITH RESPECT TO CLIMATE CHANGE

**A-1** Sample criteria for identification of key vulnerabilities of an organization with respect to climate change:

a) Magnitude and distribution of impacts — The magnitude and distribution of an impact is determined by its scale (for example, the area or number of people affected) and its intensity (for example, the degree of damage caused).

b) Timing of impacts — A harmful impact is more likely to be considered as 'key Impact' if it is expected to happen soon rather than in the distant future.

c) Persistence and reversibility of impacts — Examples of impacts that could become key due to persistence include the emergence of near-permanent drought conditions and intensified cycles of extreme flooding that were previously regarded as 'one-off' events.

d) Likelihood (estimates of uncertainty) of impacts and vulnerabilities, and confidence in those estimates — Likelihood of impacts and our confidence in their assessment are two properties often used to characterize uncertainty of climate change and its impacts. Likelihood is the probability of an outcome having occurred or occurring in the future; confidence is the subjective assessment that any statement about an outcome will prove correct. Uncertainty may be characterized by these properties individually or in combination.

e) Potential for adaptation — To assess the potential harm caused by climate change, the ability of individuals, groups, societies and nature to adapt to or upgrade adverse impacts must be considered

f) Importance of the system(s) at risk — This point can be best described by the following situation-the transformation of an existing natural ecosystem may be regarded as important if that ecosystem is the unique habitat of many endemic species or contains endangered charismatic species. On the other hand, if the livelihoods of many people depend crucially on the functioning of a system, this system may be regarded as more important than a similar system in an isolated area.

**A.2** The following table illustrates through examples how fields of action, new or existing, can affect climate change and biodiversity factors.

| Sites and Facilities | Supply Chains and Commodities | Product | Manufacturing Processes | Logistics | Personnel |
|---|---|---|---|---|---|
| **Space required**<br>**Habitat fragmentation** | Space required for production | Area and volume requirement of the product | Land needed for production facilities<br>Discharge of heated waste water | Space required for roads and storage<br>Roads and pipelines cross migratory species routes | Habitats constructed in an employee volunteering project |
| **Power demand and carbon dioxide ($CO_2$) emissions of buildings**<br>**Ground storage of carbon dioxide ($CO_2$)** | Power demand and carbon dioxide ($CO_2$) emissions<br>Depletion of Carbon sink | Ozone depleting substances | Power demand and carbon dioxide ($CO_2$) emissions<br>Need for ozone-depleting substances in production | Power demand and carbon dioxide ($CO_2$) emissions caused by transportation | Employee behaviour impacts power demand and therefore greenhouse gas emissions |
| **Site location may accommodate invasive species** | Cultivation of new non-native resources | Product design may lead to spreading of invasive species | Production processes may promote spreading of invasive species | Spreading of invasive species by transport of resources and products | Employee behaviour has impact on spreading of invasive species |
| **Drainage of wetlands**<br>**Erosion caused by agriculture** | Homogenization of agriculture<br>Monoculture | Service features and product attributes can have an impact on biodiversity | Excessively sized facilities may generate increased demand for resources and lead to over exploitation | Parking space management | Employee behaviour has impact on biodiversity |
| **Release of climate gases from depletion of forests and drainage of wetlands, Dust, Building shadows** | Over fertilization, Wastewater | Product usage may cause emissions (for example, waste-water, noise, air pollutants)<br>Product as waste | Wastewater<br>Emissions | Separation of oil<br>Detergent and waste water Particulate matter | Emissions caused by employee business travel |

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(*Continued from second cover*)

c) To critically examine manufacturing practices of products to be aware from claims of green washing.
d) To support green productivity.
e) To generate sectoral data banks for each activity and product category.

This standard helps to better understand efficiency of infrastructure, equipment, material and energy use practices via development of matrices of all inputs including equipment, materials, energy, water, wastes, emissions and effluents that track and quantify them.

Many organizations may not be aware of green manufacturing concepts with which one can assess the factors leading to inefficiency, material losses and higher environmental burdens. However, once the information is available in the form of matrices, it can be easily used to seek opportunities to resource conservation, efficient uses of material and energy, reduce adverse environmental impacts and associated costs.

This standard is applicable to all the industries that use materials and energy, including extraction, manufacturing, services, etc. It can be implemented by all organizations without any existing systems in place such as environmental management systems.

The Guidelines standard is expected to provide tools for efficient manufacturing and environmental management and can be used by single organization or extended to multiple organizations within a supply chain, to help develop an integrated approach to adopt efficient practices, use of materials and energy.

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This Indian Standard has been developed from Doc No.: CHD 34 (11416).

## Amendments Issued Since Publication

| Amend No. | Date of Issue | Text Affected |
|---|---|---|
| | | |
| | | |
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| | | |

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Published by BIS, New Delhi